Comparison between Elliptical and Squared ROI to Launch an Automatic Seed to Region Growing Algorithm on Hepatic Segmentation using CT images

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Abstract— **Early detection of liver cancer increases the survival rate by 60-70% in five years. As part of CAD development for the liver, two automatic seed selection techniques (for automatic liver segmentation using region growing technique) are compared, using the calculation of Mean Squared Error (MSE) to analyze which one has the lowest error when compared with manual segmentation. Was used 2631 liver computer tomography slices, the first step is make the pre-process of these slices with the windowing and then, is applied a mean filter with the gamma transformation. The first technique defines the Seed Launch on Elliptical Area (SLEA) for find the seed point, and the second technique defines the Seed Launch into Square Area (SLSA) for find the seed point. And the seed points that were found with each one of these techniques are used to perform the liver segmentation with the region growing algorithm, and from the liver segmented is performed the entire exam volume and the MSE calculation for each technique, and these results compared with the manual segmentation. The average liver volume measured manually was of 1,388.41 cm^3, and with SLEA technique the average liver volume measured automatically was of 1.663,59 cm^3 and the average MSE was of 68.69±96.35 cm^3, and for the SLSA technique the average liver volume measured automatically was of 1,661.43 cm^3 and the average MSE was of 193.16±286.84 cm^3. The smallest MSE SLEA was of 2.035 cm^3 and the bigger was of 391.815 cm^3, and for the SLSA the smallest MSE was of 2.122 cm^3 and the bigger was of 1,110.824 cm^3. Thus was observed that both techniques have the average volume similar, but the SLEA technique has the smallest values and averages of the MSE.**

Keywords— **Elliptical area, Squared area, Region Growing, Automatic seed launch, Liver segmentation.**

I. Introduction

The liver cancer is highly complexity to be diagnosed and treated [1]. In patients who had liver cancer detection in advanced stages, the survival rate at five years was only 15%, however when this type of cancer is detected in early stages, this survival rate rises to 60-70% in the same period [2].

The best way to reduce cancer mortality is to perform an early detection, in other words, prevention. The Computer Tomography (CT) exam of the abdomen is often used for analysis of liver lesion, but is required a methodology that is more reliable and accurate to assist the radiologist in the differentiation of malignant and benign hepatic lesions. [3]

It is required a good method to do the liver segmentation and build reliable and accurate Computer Aided System (CAD). In this work is used region growing technique to do this liver segmentation, and the choice of the seed point is automatic.

The selection of the seed point, a fundamental process for the correct operation of this segmentation technique [4, 5, 6], is influenced by the amount of structures present in the area (with a gray level close to the liver).

The objective of this work is to compare two techniques for the automatic seed selection (square area and elliptical area) evaluating the error present in each of them and comparing the result of segmentation (volume of the slice and of the exam) to the gold standard.

II. Materials and methods

From the CT slices of the abdominal region that containing the liver is realized the windowing CT process, the preprocess step starts by the applying a mean filter to reduce noise and in sequence a power law transformation (gamma) is applied in order to improve the contrast of the liver and other structures that exist in image.

After preprocess, is performed a search by seeds points using each one of the techniques proposed, and the results are stored.

The result of the seed points search is used as a parameter for the segmentation algorithm (region growing algorithm), where the output is a monochromatic image with segmented liver. Being the volume measured in this monochromatic image.

In the Figure 1 below is shown this process that has been described above.

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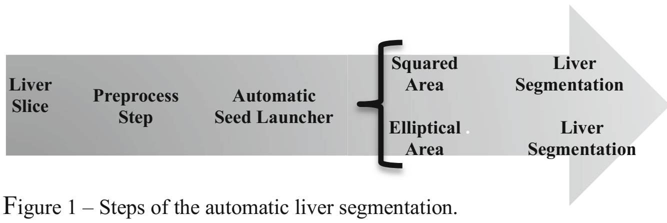

Figure 1 – Steps of the automatic liver segmentation.

The manual segmentation is also done by a specialist, and then calculated the volume of this segmentation. These segmentation and volume are considered gold standard.

A. Used images

In developing of this work 2631 CT slices of the abdominal area that had radiological contrast application were used, that correspond a sixteen CT exams, which were stored in the database of a public hospital in Brazil.

All slices were obtained from the same CT equipment, model Aquilion 64 of the Toshiba Medical Company.

These slices were on DICOM [7] standard, which has size of the [512x512] pixels and stored in 16 bits.

B. Preprocess step

To have a best results on liver segmentation, is applied the windowing process and then power law transformation is applied on slice, and for noise reduce is used a mean filter [8].

a) Windowing

Each slice is submitted to windowing process, and the necessary information are read from the DICOM headers Window Center – WC (DICOM tag 0028, 1050) [7] and Window Size – WS (DICOM tag 0028, 1051) [7]. This is done according with Equation 1, below:

$$Px = \begin{cases} \left(\frac{WS}{2}\right) - WC, se\ Pi \le ((WS/2) - WC) \\ \left(\frac{WS}{2}\right) + WC, se\ Pi \ge ((WS/2) + WC) \\ PxIn, \quad Otherwise. \end{cases} \quad (1)$$

Where:

"Px" is the output pixel value, "Pi" is the input pixel value, "WC" is the window center value, and "WS" is the window size value.

b) Mean filter with power law transformation

In the images is applied the mean filter [4] [3x3] size and in sequence a power law transformation [4] (Equation 2), with gamma factor of 0.5.

$$Px = C * Pi^{\gamma} \quad (2)$$

Where:

"Px" is the output Pixel value, "C" is a constant (in this case C=1), "Pi" is the input Pixel value and "γ" is the correction gamma factor.

C. Automatic seed launch

The automatic seed launch is done for each slice, the first part of the algorithm is the bone selection, removing all pixels (defined as background value) with the gray level is below to the bone based on Hounsfield Unit (HU) [9], so is obtained the coordinated for the bones (ribs) and defined the internal area of the abdomen. By the a priori knowledge of the region where the liver this, the seed search area is reduced to only to the left portion of the slice [10].

The two techniques that will be presented in sequence are using the coordinates of the bones found to limit the area of search seeds, considering only the intra ribs area.

a) Seed launch on squared area

To define the Seed Launch in Square Area (SLSA), is considered only the intra ribs area, a rectangular area is defined, considering the left side of the image, counting 60 pixels (towards the center) from the coordinates of the bone more distant of the center of the slice, in four directions (right, left, top and bottom). In Figure 2 can be observed an example of the area selection for the seed launch (Figure 2a original slice, Figure 2b zoom on SLSA and on Figure 3c the seed point).

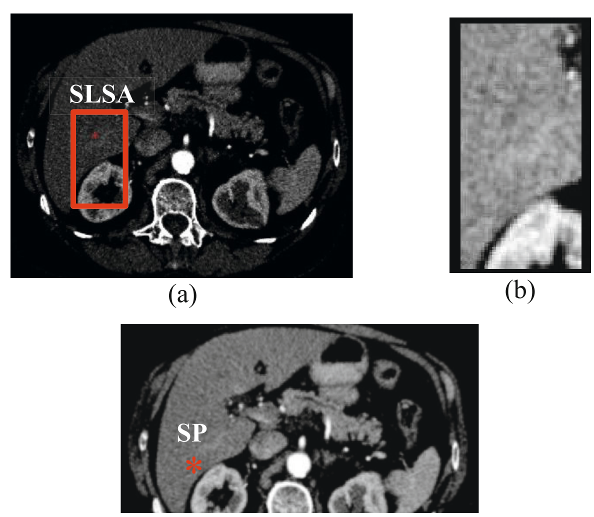

Figure 2 – (a) Original Slice; (b) Square area for automatic seed launcher; (c) Automatic Selected Seed Point on Square Area.

When the area is defined, occurs a search for sets of pixels within the SLSA, being limited the search for the liver gray level (considering HU [9] value). From the group of points found, is calculated the region centroid [11] and then is calculated the mean of these pixels values, the result is considered as the Seed Point (SP) of SLSA (Figure 2c).

b) Seed launch on elliptical area

The Seed Launch in Elliptical Area (SLEA) is defined on the basis of intra ribs area (defined previously) that was automatically determined. Based on this coordinates is defined the ellipse area location and its size, in Figure 3b has an example of an elliptical area defined, in Figure 3a it is the entire slice with the elliptical area demarcated and in Figure 3c is the seed point of SLEA.

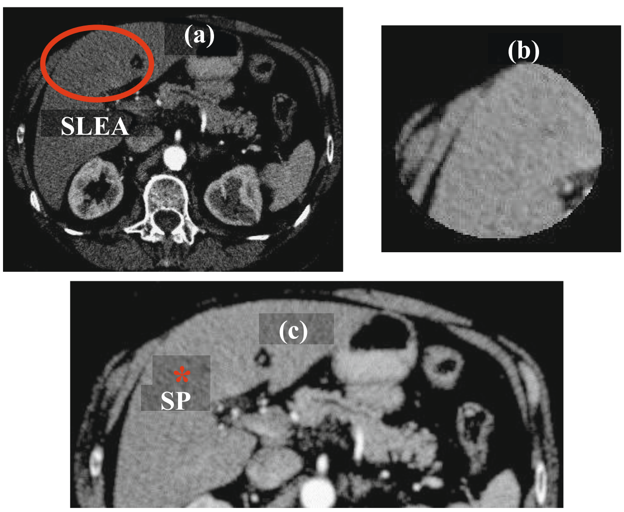

Figure 3 – (a) Original Slice with SLEA, (b) Elliptical Area, and (c) Automatic Selected Seed Point on Elliptical Area.

A search for sets of pixels in the SLEA is done, using the HU [9] gray scale for liver. From this group of points found, is calculated the region centroid [11] and then calculated the mean of these pixels values, and the result is considered as the Seed Point (SP) of SLEA (Figure 3c).

D. Region growing

The region growing [4] [10] [12] algorithm do the area segmentation, from the seed point, based on grouping similar pixels (using the gray level) to the seed point. The output image is monochromatic and the pixels with values equals to one are result of segmentation.

All images are processed using the two seed launch methods. Thus these images are separated into two automatic hepatic segmentation groups, the group 1: images processed by using the SLEA techniques; and the group 2: images processing by using the SLSA technique.

E. Volume calculation

The volume calculation is done, considering division of the groups and of the exams, using the segmentation output image, by adding the pixels with the value equals to one and multiplying then by some DICOM tags: Spiral Pitch Factor, that represents the space between consecutive slices, and Pixel Spacing, that represents the size of pixel in millimeter. The equation for volume calculation is showed on Equation 4, where “Vol” is final volume of the slice,”Sl” is the segmented image of liver, “SPF” is the spiral pitch factor value and “PS” is the pixel spacing value.

$$Vol = \sum_{i=0}^{512}\sum_{j=0}^{512}(Sl(i,j) * SPF * PS) \quad (4)$$

Thus is obtained the volume in cubic millimeters (mm^3), for easy comparison with literature the volume is converted for cubic centimeter (cm^3).

F. Manual segmentation

To have a comparison standard was requested to a specialist to perform a manual segmentation of the same set of images doing the measure of the volume and the area.

The open source software ImageJ [13] was used to do the manual segmentation.

G. Statistical analysis

Was used the Mean Squared Error (MSE) [14] for statistical analysis, this calculation is performed according to Equation 5. Where “MSE” is the mean squared error of the exam, “n” is the total exam slices, “Ŷi” is the automatic volume of the slice and Yi is the manual volume of the slice.

$$MSE = \frac{1}{n}\sum_{i=1}^{n}\left(\hat{Y}_i - Y_i\right)^2 \quad (5)$$

This calculation was performed for the segmented images using the SLEA and SLA techniques.

III. Results

Performing the described procedures, a mean volume of 1,663.59 cm^3 was reached using the SLEA and with SLSA the mean volume reached was of 1,661.43 cm^3, and the average liver volume measured manually was of 1,388.41 cm^3. The MSE is showed in Table 1, in the first column is observed the exams numeration, in the second column is showed the MSE between manual and SLEA segmentation and on third column is showed MSE between manual and SLSA segmentation.

Table 1 – MSE of volumes in cubic centimeter (cm^3).

Exams	Mean Squared Error (cm^3)	
	Group 1 (SLEA)	Group 2 (SLSA)
1	17.307	6.387
2	*2.035*	*2.122*
3	2.955	87.399
4	10.473	21.742
5	18.719	105.531
6	14.327	19.431
7	55.251	70.669
8	9.388	14.812
9	160.165	211.108
10	86.276	86.706
11	*391.815*	511.517
12	24.174	450.359
13	70.700	*1110.824*
14	39.687	42.199
15	40.464	40.085
16	104.0562	122.850
Mean ± SD	**68.699 ± 96.35**	**193.157 ± 286.84**

IV. DISCUSSION

Thus was observed that despite the final volume of the SLEA and of the SLSA be similar, when was observed MSE was not noticed this similarity.

The smallest MSE was detected for the SLEA (mean of 68.699 ± 96.35 cm^3), with the best result observed on exam 2 with 2.035 cm^3 of error and the worst results was noted on exam 11 with 391.815 cm^3 of error. And the mean of the MSE found for the SLSA was 193.157 ± 286.84 cm^3, in this case the best result are on the exam 2 with 2.122 cm^3 and the worst result observed on exam 13 with 1,110.824 cm^3.

Using the seed launch on the elliptical area for region growing segmentation was observed the smallest error considering these results.

V. CONCLUSIONS

With the proposed procedure both techniques showed final volume similar, comparing the average of all exams, but SLEA technique has a smallest error for seed launch.

Thus it can be conclude that the shape of seed launch region influence in the region growing segmentation error, when it is compared with the manual segmentation.

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CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

REFERENCES

1. INCA – Câncer de Fígado at http://www.inca.gov.br/conteudo_view.asp?id=330
2. AMERICAN CANCER SOCIETY. Liver cancer survival rates at http://www.cancer.org/cancer/livercancer/detailedguide/liver-cancer-survival-rates
3. Huang Y-L, Chen J-H, Shen W-C (2006) Diagnosis of Hepatic Tumors With Texture Analysis in Nonenhanced Computed Tomography Images. Academic Radiology. 13(6):713—720 DOI 10.1016/j.acra.2005.07.014
4. Gonzalez RC, Woods RE (2008) Digital Image Processing. Prentice Hall, New Jersey
5. Wu J, Poehlman S, Noseworthy MD, Kamath MV (2009) Texture feature based automated seeded region growing in abdominal MRI segmentation. Journal of Biomedical Science and Engineering. 2:1-8 DOI 10.4236/jbise.2009.21001
6. Gambino O, et al. (2010) Automatic Volumetric Liver Segmentation Using Texture Based Region Growing, International Conference on Complex, Intelligent and Software Intensive Systems (CISIS), Krakow, Poland, 2010, pp 146—152 DOI 10.1109/CISIS.2010.118
7. DICOM at http://dicom.nema.org
8. Anastácio R., et al. (2015) Preprocess Enhancement of CT Image for Liver Segmentation with Region Growing Algorithm, IFMBE Proc. Vol. 45, 6th European Conference of the International Federation for Medical and Biological Engineering, Dubrovnik, Croatia, 2014, pp 134—137 DOI 10.1007/978-3-319-11128-5_34
9. Berber E, et al. (2000) Use of CT Hounsfield unit density to identify ablated tumor after laparoscopic radiofrequency ablation of hepatic tumors. Surg Endosc., 14(9): 799—804.
10. Kumar SS, Moni RS, Rajeesh J (2013) Automatic liver and lesion segmentation: A primary step in diagnosis of liver diseases. Signal, Image and Video Processing, 7(1): 163—172, DOI 10.1007/s11760-011-0223-y
11. Geometric Centroid." From MathWorld – A Wolfram Web Resource. at http://mathworld.wolfram.com/GeometricCentroid.html
12. Jayanthi M, Kanmani B. (2014) Extracting the Liver and Tumor from Abdominal CT Images, 5th International Conference on Signal and Image Processing (ICSIP), Jeju Island, South Korea, 2014, pp.122—125. DOI 10.1109/ICSIP.2014.24
13. Abràmoff MD, Magalhães PJ and Ram SJ. (2004) Image Processing with ImageJ, Biophotonics International, 11(7): 36-42
14. Dodge Y (2008) The Concise Encyclopedia of Statistics. Springer, German DOI 10.1007/978-0-387-32833-1

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